E546 : Measurements of Electronic X rays correlated with Pionic X rays

Negative pions stopped in matter result in the formation of pionic atoms. The pions exist in highly excited states at the beginning of the capture process, and then they cascade down to lower excited states by emitting πX rays or Auger electrons. Moreover Auger electrons emission is followed by electronic X-ray (eX-ray) emission from pionic atom. The characteristic X-ray energies of pionic atoms are not those of target atom (atomic number Z) but close to those of Z-1 atom. In E546, we examined electronic X-ray emission correlated with each pionic X ray to understand electronic rearrangement in the pionic atom during the pionic cascade.

The measurements were performed at πμ-channel of KEK-PS. As illustrated in Fig 1, the measuring system consists of four plastic scintillation counters and three Ge detectors. The signals from Ge detectors were taken in the coincidence with the stop events by PS1, PS2, PS3 and veto PS4. To examine the correlation between πX rays and eX rays, the photon events are recorded in a list mode. We used Mo, Sn, Dy, Ho, Ta and Pb metals and Mo, Sn, Ba, Nd, Gd, Ho, Yb and Hg oxides as the target. The typical pion beam intensity was about $5x10^4$ π^- per pulse. In addition, we measured eX-ray energies of these atoms and their Z-1 atoms induced by photo ionization with a Co-57 source in the same apparatus.

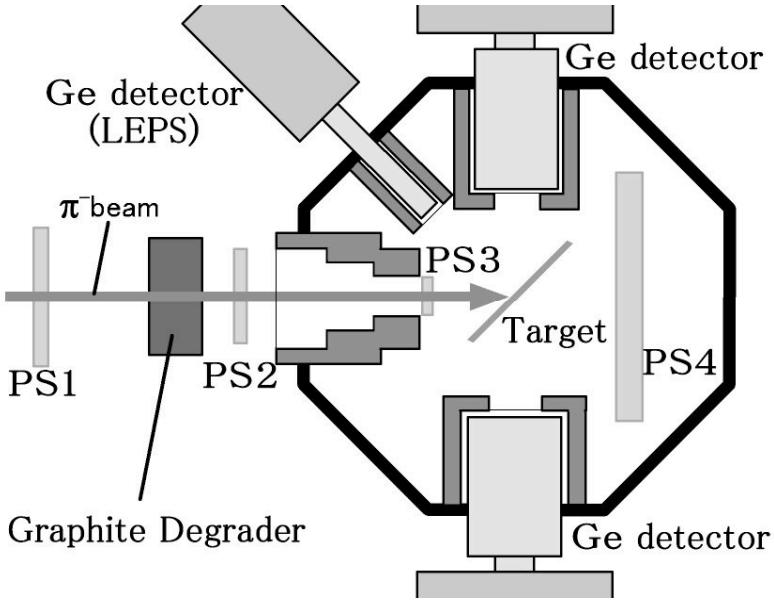
We tried to measure the electronic X rays emitting in each excited state of a pionic atom. However, the number of correlated events is too small to discuss the difference of electronic X-ray energy between pionic states quantitatively. Here, we used the gross spectrum for analysis. The energy shifts were found in both K_α and K_β lines of almost targets. We show atomic number dependence of the energy shifts of the K_α ray in Fig 2, together with those for muonic atoms obtained by other group.

We also try to reveal the atomic and molecular states after the pion capture by measuring eX rays correlated with πX rays. In this purpose, we extracted eX ray signals correlated with πX ray from the obtained spectra and examined the difference in the fine structure of KX rays (the ratio of K_α to K_β X rays) between metal and its metal oxide for Sn and Mo. However, the number of correlated events is too small to discuss on the difference quantitatively.

Figure captions

Fig. 1. Schematic drawing of experimental arrangement.

Fig. 2. Energy shifts of the eX rays. This work is showed in filled squares and triangles. The shifts in muonic atoms are also illustrated with open squares.



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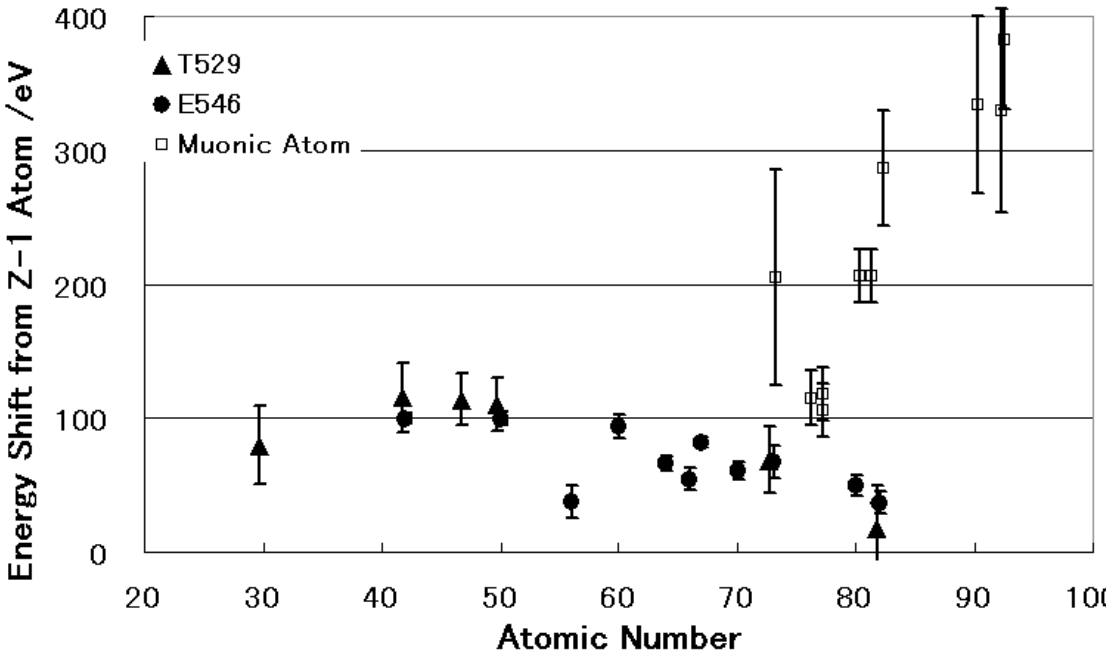

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